Partnering with Occupational Therapists for First-Year Design Projects

Dr. Todd France, Ohio Northern University

Todd France is the director of Ohio Northern University's Engineering Education program, which strives to prepare engineering educators for the 7-12 grade levels. Dr. France is also heavily involved in developing and facilitating the Introduction to Engineering course sequence at ONU. He earned his PhD from the University of Colorado Boulder where his research focused on pre-engineering education and project-based learning.

Dr. J. Blake Hylton, Ohio Northern University

Dr. Hylton is an Assistant Professor of Mechanical Engineering and Coordinator of the First-Year Engineering experience for the T.J. Smull College of Engineering at Ohio Northern University. He previously completed his graduate studies in Mechanical Engineering at Purdue University, where he conducted research in both the School of Mechanical Engineering and the School of Engineering Education. Prior to Purdue, he completed his undergraduate work at the University of Tulsa, also in Mechanical Engineering. He currently teaches first-year engineering courses as well as various courses in Mechanical Engineering, primarily in the mechanics area. His pedagogical research areas include standards-based assessment and curriculum design, including the incorporation of entrepreneurial thinking into the engineering curriculum and especially as pertains to First-Year Engineering.

Dr. Lauren H. Logan, Ohio Northern University

Lauren H. Logan is an assistant professor of civil and environmental engineering at Ohio Northern University. Her research focuses on quantifying the impacts of thermal pollution from thermoelectric-power-plant water use on aquatic ecosystems. She earned her Ph.D. from the Energy-Water-Environment Sustainability program at the University of Illinois at Urbana-Champaign. Lauren is active in Tau Beta Pi as a District 7 Director, and the Sustainability Committee of the Environmental and Water Resources Institute (EWRI) through the American Society of Civil Engineers (ASCE). She is passionate about the recruitment and retention of under-represented minorities into engineering programs, particularly through unique and cross-disciplinary engagement.

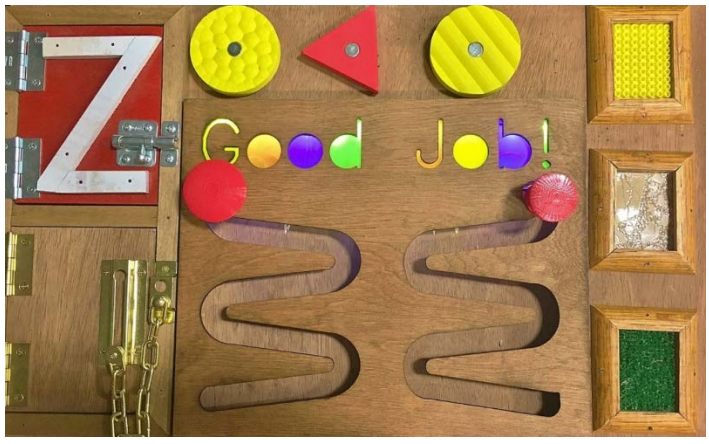
Full Paper: Partnering with Occupational Therapists for First-Year Design Projects

Background & Purpose

During the spring and fall semesters of 2017 at Ohio Northern University, an Engineering Projects In Community Service (EPICS) course was conducted in partnership with local occupational therapists (OTs). As described in a previous iteration of the project [1], human-centered design was emphasized to promote a connection between the engineering profession and social responsibility, resulting in custom-made devices that support children's fine motor skill development.

A key shortcoming, however, was the limited reach of this previous project, as it was part of an elective course with just three students per semester and which was outside the instructor's normal teaching load. A question consequently arose: *could first-year engineering students – generally inexperienced in fabrication and human-centered design – create safe, durable, and age-appropriate devices that would actually be utilized by OTs?* The second semester of the first-year engineering course sequence at Ohio Northern University, organized around a semester-long, hypothetically-contextualized project, presented such an opportunity for piloting the OT project. In spring 2018, twelve students elected to participate in this service-learning opportunity while their classmates continued with the traditional hypothetical project. These students were formed into three groups of four members each.

The OT project was successfully completed by all teams, yielding three still-in-use devices (as of ten months after delivery); this alternative project is now in its second iteration, with a total of five teams (in addition to two unrelated service-learning projects). Figures 1 and 2 show two of the delivered OT products.



Figures 1 and 2: Two of the three occupational therapy tools delivered at the end of the spring 2018 semester. Design features were categorized as "sensory" (e.g., various textures), "activities of daily living" (e.g., opening latches, flipping switches), and "prehension" (e.g., grasping, pinching). The OT project partner requested action-reaction features (e.g., opening a door to reveal a mirror) and that users be required to use both hands in some instances (e.g., in Figure 2, simultaneously moving the round pegs up the serpentine tracks lights up "Good Job!").

This paper details the strengths and obstacles of this pilot project; findings are intended to provide insight for others interested in embedding service-learning into required engineering curriculum, particularly in first-year coursework when students are still in the infancy of developing their professional mindsets.

Project Logistics

When the OT project was presented to students as an alternative, it was made clear that each finished device was expected to be delivered to a real client and any device that (1) posed risks to children (e.g., sharp edges, pinch points, electric shock); (2) lacked durability; (3) did not meet the client's wishes; (4) lacked high-quality craftsmanship; or (5) were otherwise unprofessional would not be delivered. Moreover, any undeliverable device would result in harsh penalties and low course grades. The intent of this transparency was to set a high standard and force uncommitted students to reconsider applying (students were incentivized by a larger project budget and the ability to choose their own teammates if all applied).

The overarching purpose of the introductory engineering course was to gain experience in teamwork, project management, and engineering modeling and analysis while employing design thinking to solve a contextualized, complex problem. OT teams followed the same general deadlines as their counterparts as they all progressed through a structured design process.

One advantage of the OT project from the instructor's perspective is the ease by which the device can be divided into subcomponents; team members were instructed to take individual ownership of specific features, though teammates were compelled to work cooperatively such that their fully assembled devices were cohesive and well organized. This balance of independence and interdependence, two traits supportive of a well-functioning team [2], [3] (and traits that were often more challenging to apply to the other project teams), allowed for more accurate assessment and created a sense of individual responsibility in a team-based course, a learning environment that can unfortunately lead to underperforming individuals "hitchhiking" on the efforts of more motivated teammates [4].

Research Approach

Midway through the spring 2019 semester, students were surveyed to gather insight on the OT project. Twenty-four of 28 students (including participants from both the spring 2018 and 2019 semesters) responded. The 9-question anonymous survey was distributed via email to promote honest and constructive feedback; questions were deliberately open-ended so as to limit bias and offer opportunity for elaboration on key points. For example, two sample questions were:

- Why did you choose to be part of this project?
- Do you believe you spent/spend less time, more time, or about the same amount of time on your project compared to teams working on the normal course project? Why?

Responses were qualitatively analyzed without an established set of themes to allow commonalities to emerge organically. Each answer was categorized quantitatively to help identify the strongest points overall; quoted statements that appear below were selected primarily to represent the most common viewpoints, though others were selected to represent salient points from alternative perspectives. It is recognized that this exploratory investigation has a small sample size; additional studies, both longitudinally and with increased participants, will be necessary to better support transferability of the findings discussed.

Findings

Nearly two-thirds of the respondents (15 of 24) noted that they volunteered for the project because they wanted to help others. Ten individuals referenced working with a real client and/or on a real project as a prime motivating factor. Throughout the survey, unsolicited comments about the traditional, hypothetical project's lack of authenticity surfaced, as is illustrated in the following comment:

"Because I will [be] directly impacting the lives of someone rather just a 'made up' scenario that I will most likely throw away and forget about. Can't see the result of actually helping someone."

When asked if they were glad with their choice to participate, all but two (92%) replied "yes," with one "no" due to poor interactions with teammates and one "unsure" due to the project's logistics. Two-thirds of the respondents indicated that their positive experiences were due to gaining real-world engineering experience and/or working with a client. Among the explanations (see examples below), there was a general sense that the authenticity of the project provided *motivation:*

- "I am more motivated to produce the best product since it will be delivered to a client…"
- "I wanted to help out the community rather than just myself. It motivates me to do better."

… and *pride:*

- "I was legitimately proud of the board we designed and have used it as a talking point in several interviews."

… due to *impacting the community:*

- "…my personal learning experience seemed like a bonus in comparison to the good it brings the kids who use the therapy board cube."

… something the hypothetical course project would have lacked:

- "…although it is challenging I know that all the work I am doing will be actually used in the future instead of just scraped [sic]."

One of the most common student complaints about the first-year engineering course sequence at Ohio Northern University is the out-of-class time required to complete assignments, most notably due to the group project – students generally report an average of about 5½ hours of work out of class per week. The twenty-four OT project respondents reported an average of slightly more than 8 hours of work out of class per week, a 45% increase. However, only two students voiced complaints about this additional effort.

Why did the participants devote more so much more time? A full two-thirds pointed to a need to be professional, for example:

- "This project required near perfection with the products created, and I believe that this pushed my team to provide the best quality we possibly could."
- "Attention to small details that may typically be unnecessary for other projects definitely added time to the design and fabrication process."

Respondents contrasted this to the hypothetical course project that only had to, as one OT project participant noted, "work in theory not in real life" and that those project teams could "neglect certain aspects" since their projects would not actually be put into use.

In response to the question, "Do you believe anything you've learned / will learn as part of the project will benefit you as a future engineer?" all but one participant responded "yes" (this individual pointed out that he was a transfer student and had already taken "many classes much harder" than the first-year engineering courses). Explanations of the project strengths varied widely, from gaining real-world engineering experience / working with a client (11 respondents) to learning to work better in teams (9) to improving fabrication skills (5), among other reasons. A common response is demonstrated by the following:

- "*I think the most valuable thing that I learned through the project was how to communicate and design for an actual client.*"

On the other hand, students voiced few complaints. The most common issues were about team dynamics (3 respondents; e.g., "[I] have learned how to be extremely frustrated with people but still able to work on a project without yelling at them, takes a lot of practice.") and misalignment with the hypothetical course project's instructions and deadlines (3). Others pointed out that they would have preferred more interaction with the client (3), while two noted that the project was more stressful since, for example, "…there are a lot more considerations to think about."

Discussion

"A big difference between the two projects was that our therapy device was actually going to be used in a classroom setting where students were most likely going to misuse it, so we had to make sure our device could withstand these stresses while also being a safe toy for the kids to play with."

Although the OT project was originally conceived as a way to improve students' fabrication skills and design thinking, as it turns out, the key takeaway of this service learning project is that by including an actual client, students became more motivated and willing to invest additional effort into their projects. This finding is consistent with the literature (e.g., [5]), which suggests positive correlation between service-learning courses and student motivation and retention, among other positive factors.

Notably, interactions with the clients have been minimal. In spring 2018 for example, a single conference call was conducted at the start of the semester for all teams to ask questions of the OT, two individuals visited the OT and her students at the semester midpoint, and a handful of clarifying questions were sent via email. This is to say that arranging a series of extensive

interactions between students and clients may not be necessary to strongly influence student motivations, though doing so would likely improve students' experiences. For instance, one of the students who visited the OT wrote: "Our group benefited the most from actually visiting the school and seeing the students. We had to make several adjustments to our project after that because we realized our project would be too close to the kids [sic] chest to play with if we put it on their desk."

One option to strengthen motivation without organizing potentially time-consuming student-client interactions is to simply include photographs of the end users, as one respondent pointed out: "Show pictures of the kids playing with the projects at the beginning so that when you want to quit you have a face in your head to push you to keep going." Yet even with this intervention, other communication pitfalls might remain; one challenge noted by course instructors included longer-than-expected delays when requesting client feedback. Additionally, the communication loop sometimes includes superficial client feedback (e.g., "great job"). Facilitating a more structured initial information gathering session and establishing clearer client expectations might serve to strengthen future interactions.

Remarkably, the most commonly cited project feature – that is, the benefit of working to serve a client's needs – was entirely student initiated. By design, none of the survey questions made any mention of clients, customers, users, project partners, etc. This adds considerable support to the key finding that including an external client in a course project can greatly leverage student engagement. While the scope and depth of this preliminary investigation limit this finding's transferability, it is conceivable that including a client – any client – is worthwhile, as one respondent recommended to the course instructors: "I would keep doing this project in the future or seek out different real clients to have for the freshman."

An additional benefit of human-centered design projects is the ease by which students can realize the direct connection between engineering and helping others, a strength of the discipline that is often misunderstood [6], [7]. This is particularly valuable for retention of female students. Women leaving STEM fields often cite a feeling that those fields do not align with their interests, which are often focused around communal goals such as helping others [8]. Women have also been shown to emphasize altruism, knowledge development, and interpersonal orientation as motivating factors in their career choice (Dasgupta and Stout) – all factors in which a client-situated, service-focused, team-based project may be particularly valuable as a retention and motivation tool.

While there was not overwhelming interest from female students in the OT project (23% of participants were females compared to 14% of the general first-year engineering population), it is a step in the right direction. It is important to note that, sometime in the early college years, the primary factors in women leaving/pursuing STEM fields shifts from interest-oriented factors such as above to mentorship and feeling-of-belonging factors [9]. Being in the first year of the college experience, however, projects such as this can provide an important hook for new students until the mentorship and networking elements are able to be established. Additionally, providing (and marketing!) this and similar human-centered projects may help with the recruitment of female students in the future.

In summary, this paper presents a low-barrier-to-entry occupational therapy project that engages first-year engineering students interested in helping those in need. As the literature suggests, students' interest in helping others can serve as a hook for first-year students to engage with and remain in engineering. Furthermore, projects like the OT project described in this paper might serve to improve retention, particularly of female engineering students. The OT project also supports motivation by including a real-world, yet infrequently-consulted, client. This motivation empowers students to work harder without complaint, and results in secondary outcomes such as improved teamwork and fabrication skills. As one student put it, *"The lessons that I have learned through this project have already helped me receive an internship for this summer."* This development of recruiter-valued skills is in line with past work [10], suggesting that client-based interactions improve students' career skills. Students' enhanced fabrication abilities may also serve to further promote motivation by helping students develop confidence in engineering skillsets. Creating connections between engineering and community engagement through projects like the OT project, coupled with project outcomes such as improved teamwork and fabrication skills, helps students realize that their chosen career paths can indeed allow them to help those in need.

References

[1] France, T. (2018, June). "Occupational Therapy Boards: Identifying the Value of a High-Impact Service-Learning Project." Paper presented at the ASEE National Conference & Exposition, Salt Lake City, UT.

[2] Felder, R. M., & Brent, R. (2004). *The ABCs of Engineering Education: ABET, Bloom's Taxonomy, Cooperative Learning, and So On*. Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition.

[3] Smith, K. A., Douglas, T. C., & Cox, M. F. (2009). Supportive Teaching and Learning Strategies in STEM Education. In R. G. Baldwin (Ed.), *Improving the Climate for Undergraduate Teaching and Learning in STEM Fields: New Directions for Teaching and Learning*, 117, 19-32.

[4] Kaufman, D. B. & Felder, R. M. (2000). Accounting for Individual Effort in Cooperative Learning Teams. *Journal of Engineering Education, 89*(2), 133-140.

[5] Bringle, R., Hatcher, J., & Muthaih, R. (2010). *The Role of Service-Learning on the Retention of First-Year Students to Second Year*. Michigan Journal of Community Service Learning, 16(2), 38-49.

[6] Svinicki, M. D. (2010). A Guidebook on conceptual frameworks for research in engineering education. *Rigorous Research in Engineering Education NSF DUE-0341127, DUE-0817461*.

[7] Katehi, L., Pearson, G. & Feder, M. (Eds.). (2009). *Engineering in K-12 Education: Understanding the Status and Improving the Prospects*. Committee on K-12 Engineering Education. National Academy of Engineering and National Research Council of the National Academies. Washington, D.C.: The National Academies Press.

[8] Su R., Rounds J., Armstrong P. I. (2009). Men and things, women and people: A meta-analysis of sex differences in interests. Psychological Bulletin, 135, 859-884.

[9] Dasgupta, N., & Stout, J. G. (2014). *Girls and Women in Science, Technology, Engineering, and Mathematics: STEMing the Tide and Broadening Participation in STEM Careers*. Policy Insights from the Behavioral and Brain Sciences, 1(1), 21–29. https://doi.org/10.1177/2372732214549471

[10] Cooke, L., & Williams, S. (2004). *Two approaches to using client projects in the college classroom.* Business Communications Quarterly, 67, 139-152.